Scientific Inquiry

PS-1 The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

PS-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.
Taxonomy Level: 3.1-C Apply Procedural Knowledge

Key Concepts:
Reading scientific measuring instruments:
graduated cylinders, balances, spring scales, thermometers, rulers
Measurement data
Metric units
Precision and accuracy

Previous/Future knowledge: In the 1st grade students used rulers "accurately and appropriately" (1-1.2) but only used standard English units of measurement. In the 2nd grade students used thermometers and balances (2-1.2). By the 3rd grade students used meter tapes and graduated cylinders (3-1.5) and by the 6th grade spring scales and beam balances are used (6-1.1). In Physical Science the students will record measurement data in appropriate metric units using the correct number of decimals by estimating the last digit on the measurement scale of the instrument. Significant figures will be addressed in Chemistry (C-1.1) or Physics (P-1.1).

It is essential for students to
- Read scientific instruments such as graduated cylinders, balances, spring scales, thermometers, rulers, meter sticks, ammeters, voltmeters (or multimeters), and stopwatches using the correct number of decimals to record the measurements in appropriate metric units.
- The measurement scale on the instrument should be read with the last digit of the recorded measurement being estimated.
- Record data using appropriate metric units (SI units). They should be able to use prefixes; milli, centi, kilo. (Conversions should be made using dimensional analysis – see PS 1-5)
- Understand that the more decimals in the recorded measurement, the greater the precision of the instrument.
  - An instrument that can be read to the hundredths place is more precise than an instrument that can be read to the tenths place.
  - A 100 mL graduated cylinder that is marked in 1 mL increments can be read exactly to the ones place with the tenths place being estimated in the recorded measurement.
  - A 10 mL graduated cylinder that is marked in 0.1 mL increments can be read exactly to the tenths place with the hundredths place being estimated in the recorded measurement.
  - The 10 mL graduated cylinder, therefore, is more precise than the 100 mL graduated cylinder.
- Understand that the terms *precision* and *accuracy* are widely used in any scientific work where quantitative measurements are made**.**
  - ***Precision*** is a measure of the degree to which measurements made in the same way agree with one another.
  - The ***accuracy*** of a result is the degree to which the experimental value agrees with the true or accepted value.
  - It is possible to have a high degree of precision with poor accuracy. This occurs if the same error is involved in repeated trials of the experiment.

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It is not essential for students

- to identify the number of significant figures in measurements or
- to understand their use in calculations;
- to understand the difference between systematic and random measurement errors, or
- to define the degree of uncertainty of measurements.

Assessment Guidelines:

The major objective of this indicator is to *use* scientific instruments to record measurement data in appropriate metric units reflecting the precision and accuracy of each instrument, therefore, the primary focus of assessment should be to apply proper procedures to using instruments and record the data from the instruments accurately. Assessment items will require that students understand precise and accurate measurements and that all measurement data must have appropriate metric units associated with the digits.

In addition to *use*, assessment may require that students:

- *Exemplify* precise and accurate measurements;
- *Compare* precise vs. accurate measurement data;
- *Summarize* accuracy and precision with specific scientific instruments in making measurements;
- *Infer* that measurements vary in precision and accuracy;
- *Identify* the appropriate instrument that meets the measurement need and appropriate precision for a designated experiment.